

# Planning for a Geologic Storage Demonstration in the Ohio River Valley Region



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Schlumberger

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- **Others** – William Rike

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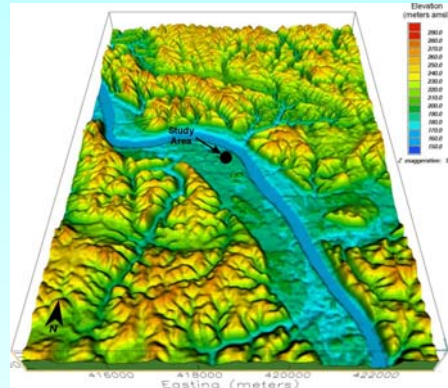
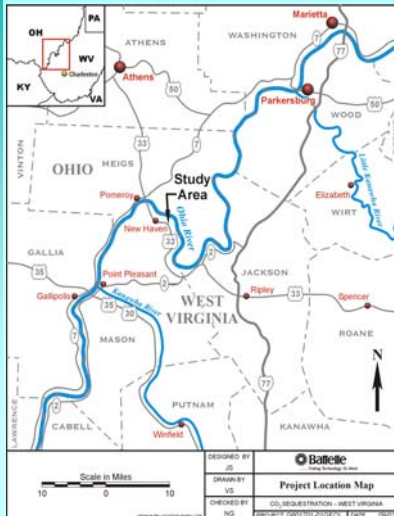
## Outline

- Introduction
- Stakeholder outreach
- Building a geologic framework
- Reservoir and caprock characterization
- Preparing the framework for potential future phases
- Conclusions and discussion

## Ohio River Valley CO<sub>2</sub> Storage Project

- During summer of 2002 DOE selected a proposal led by Battelle and supported by AEP, BP, OCDO, and Schlumberger to determine the feasibility of a geologic sequestration demonstration
- AEP offered the use of its Mountaineer Power Plant in West Virginia as the host site for this research project
- The project was formally announced by the Secretary of Energy on November 21, 2002
- The primary objective of the project is to characterize the site and its vicinity for CO<sub>2</sub> storage potential in various geologic reservoirs
- The current project is designed to be the first phase of a long-term experiment for assessment of scientific aspects and demonstration of deployment of geologic sequestration technologies

## Mountaineer Plant Location



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## Stakeholder Outreach

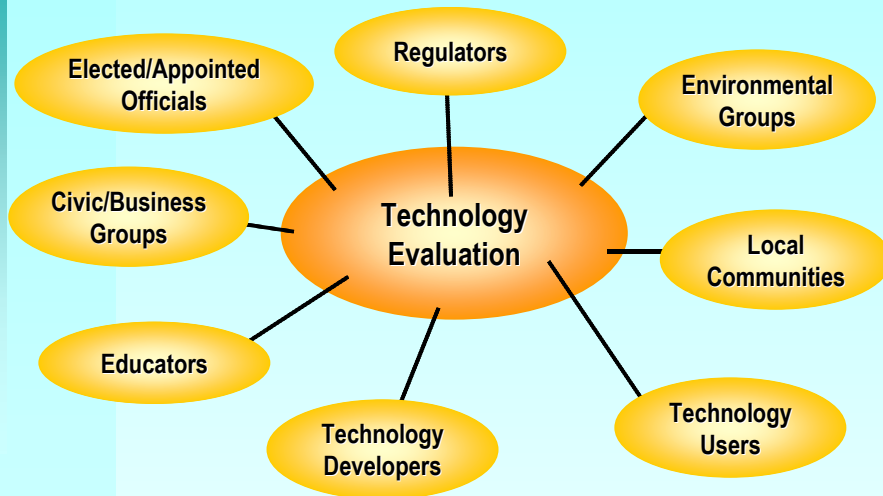
- Technical progress on this project must be accompanied by a strong outreach and stakeholder component
- Providing information to stakeholders in a timely manner is crucial for ultimate success of the project
- Listening to stakeholders at national, regional, and local levels, and taking actions to address any issues of concern are important

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## Potential Stakeholder Interactions



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## Stakeholder Outreach – Early Steps in Ohio River Valley Project

- Developed schedule and talking points for local and regional outreach
- Developed project fact sheets for distribution to public with collaboration and approval of all the project sponsors
- Numerous meetings by Battelle and AEP personnel to inform key stakeholders about the project
  - AEP managers and employees at and near the power plant
  - Regional and national NGOs
  - Local and state officials – mayors, county commissioners
  - State legislators, federal senators and congressmen
  - State PSC, Development Office, Energy Task Force
  - State DEP or EPA officials
  - Scientific meetings and workshops

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## Stakeholder Outreach – Fact Sheets

**Fact Sheet 1.2**

**Carbon Dioxide Capture and Permanent Storage:  
The Ohio River Valley Project**

**What is the purpose of the project?**

In this project, the research team is planning a field study to determine whether the deep rock structures in the Ohio River Valley is suitable for storing carbon dioxide. American Electric Power (AEP) is the lead organization. The Ohio River Valley is a major coal-producing region in the United States.

**What is the issue?**

Global warming is a major environmental concern. One of the main causes of global warming is the release of carbon dioxide (CO<sub>2</sub>) into the atmosphere. CO<sub>2</sub> is a greenhouse gas that traps heat in the atmosphere. The release of CO<sub>2</sub> from power plants and other sources is a major contributor to global warming. One of the ways to reduce CO<sub>2</sub> emissions is to capture and store it underground. This is called carbon capture and storage (CCS). CCS is a technology that can be used to reduce CO<sub>2</sub> emissions from power plants and other sources. CCS is a promising technology for reducing CO<sub>2</sub> emissions and slowing global climate change.

**Carbon Dioxide Storage Options**

1. If there is a need for such a facility, it is important to know where to store it. The carbon dioxide is released from the fuel gas after the reaction of the fuel, also called "carbon capture".

2. After release, the carbon dioxide gas is compressed, cooled, and injected into a well in the ground. The carbon dioxide is then stored in the ground for a long time.

3. The process of storing carbon dioxide underground continues while the power plant is producing electricity.

**Example of Well Design**

Oil, and other subsurface fluids, which are trapped in the rock, can be used to store carbon dioxide. The rock is called a "reservoir". The rock is usually made of sandstone or limestone. The rock is usually several hundred feet thick. The rock is usually located several miles from the surface. The rock is usually located in a "basin". The basin is a low-lying area of land. The basin is usually several miles long and several miles wide. The basin is usually located in a "basin". The basin is a low-lying area of land. The basin is usually several miles long and several miles wide. The basin is usually located in a "basin".

**Fact Sheet 1.3**

**Questions and Answers about the Ohio River Valley Project**

**Modulatory Note:**

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## Stakeholder Outreach – Next Steps

- Media coverage and stakeholder feedback has been positive so far
- Next steps may include –
  - Continued monitoring and periodic updates on project progress
  - Develop and implement strategy for national and regional NGO interactions
  - Project website for information distribution
  - Planning for data transparency and sharing strategies for the potential future phases

## Building a Geologic Framework – Deep Reservoirs

### ■ Objectives

- Compile and review available hydrogeologic data in the region
- Develop conceptual hydrogeologic framework
- Compile existing information for use in permits documents



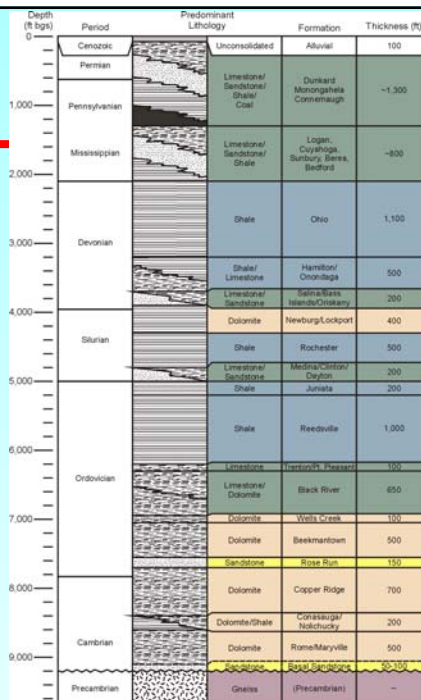
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## General Stratigraphy

- 9,200 ft or more of Paleozoic sedimentary rock overlie Pre-Cambrian rocks
- Rock layers consist of sequences of shale, limestone, dolomite, and sandstone
- Lower portions of the Maryville limestone are more porous and equivalent to the Basal Sandstone/Mt. Simon Sandstone in the region
- The Basal Sandstone and the Rose Run sandstone may be the most appealing injection targets
- Containment is excellent as the low permeability confining layers are much thicker and extensive than the injection intervals

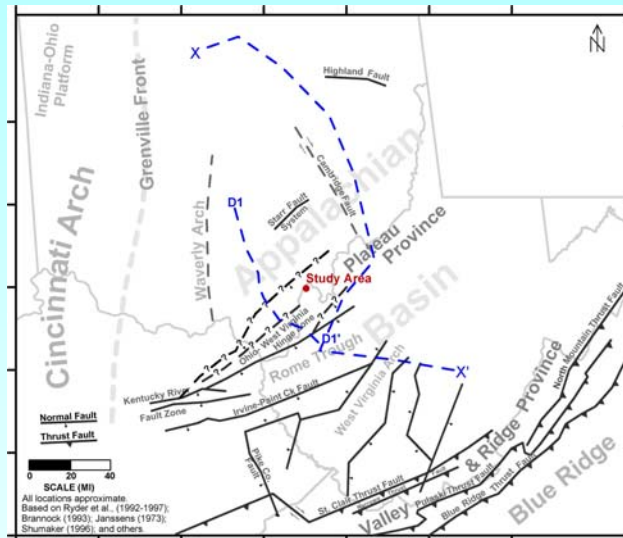


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## Regional Structural Features

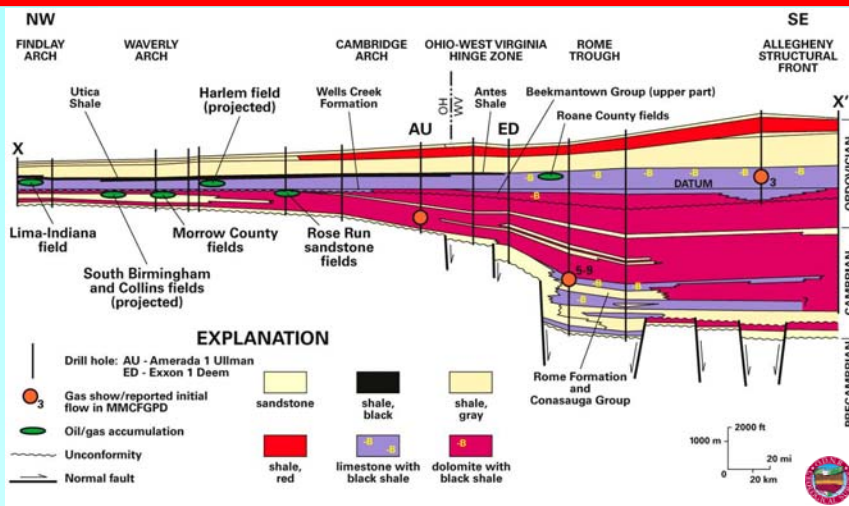


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## Cambrian and Ordovician Cross Section from Sandusky, Co., OH, to Pendleton, Co., WV

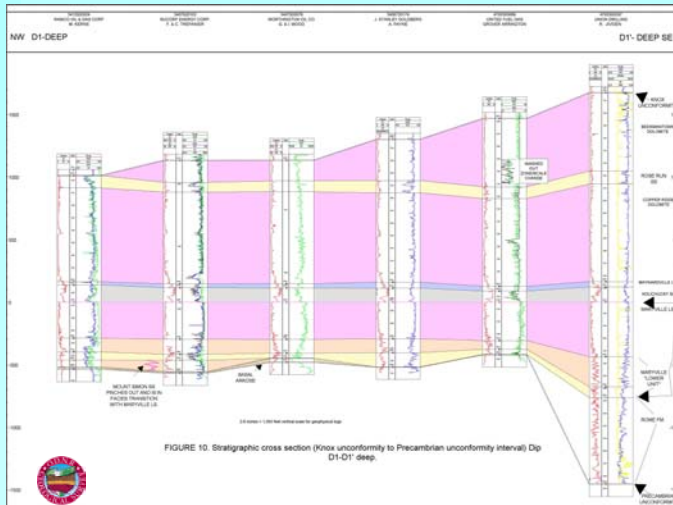


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## NW-SE Cross-Section – Below Knox Unconformity

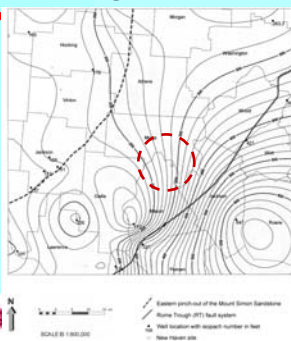


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## Geologic Framework – Potential Injection Zones



### Maryville 'Lower Unit'

- Overall Thickness of about 600 ft
- 'Lower Unit' is about 175 ft thick
- Sandstone thickness and permeability is unknown
- Roughly equivalent to the Basal Sandstone or the Mt. Simon Sandstone



### Rose Run Sandstone

- Overall thickness of Rose Run is about 125 ft
- Rose Run suboutcrops in eastern Ohio
- Some oil and gas production in portions of Ohio NW of site

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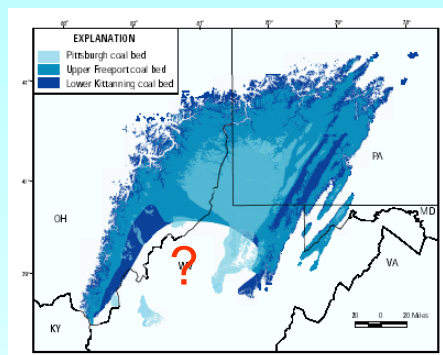
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## Geologic Framework – Hydrogeology

- Characterization, permitting, and operational aspects of deep well injection practices in the region were reviewed and pertinent data were tabulated
- Hydraulic data – permeability, porosity, rock density, pressure, fluid properties were compiled
- Lowest Underground Sources of Drinking Water (USDW) in the area were evaluated
- Available brine geochemistry data were compiled
- Injection capacity ranges were estimated

## Geologic Framework – Coal Bed Methane Potential

- There is a lack of data on the deeper coal seams in the area
- Lack of data does not necessarily mean lack of coal
- Coal mines in the area are near surface (<100 m) and not capable of CO<sub>2</sub> at pressure
- The only decisive way to determine the nature of the near-surface materials would be to obtain core samples
- Black shales layers are also likely to be present



## Reservoir and Caprock Characterization

- The field effort is aimed at characterizing CO<sub>2</sub> injection reservoirs and caprock formations
- Activities Include
  - 2-D Seismic Survey
  - Drill a deep borehole
  - Wireline logging, coring, reservoir testing, and brine collection
  - Laboratory analysis and interpretation of rocks and brine

## Reservoir and Caprock Characterization – Project Drivers

- Maximize acquisition of defensible scientific data
- Apply state of the art technology wherever possible
- Construct a well for a currently unknown set of operating conditions
- Minimize risks
  - Health and safety issues related to people and property
  - Borehole stability
- Maintain a budget!

## Reservoir and Caprock Characterization – Site Logistics

- Location, access, safety, and security
- Permitting
- Health and Safety Planning
- This project involves a combination of Oil & Gas and Power Industry regulations, rules, and policies:
  - Disparate safety standards
  - Management of investigation-derived wastes
  - Industrial discharge to surface water (Ohio River)
  - Stormwater Management
  - Wellhead Protection
  - Bulk Fuel storage
  - Chemical Storage

## Reservoir and Caprock Characterization – Mobilization

- Identify subcontractors
  - Qualifications
  - Ability to work on government funded projects
  - Stakeholder and host site requirements
  - Opportunities for small businesses
- Procurement Process
  - Competitive bids when ever possible
  - Limited sole source procurements
  - Contract terms (FAR clauses and other flow downs)

## Reservoir and Caprock Characterization - Vendor Selection

- Geophysics
  - Appalachian Geophysical Services (Data Acquisition)
  - Western Geco (Data Processing, Interpretation)
- Site Preparation awarded to local providers and small businesses
- Planning
  - William Rike – independent geologist
  - Laurel Oil and Gas
  - Schlumberger
  - BP
  - AEP

## Reservoir and Caprock Characterization - Vendor Selection

- Drilling and Support
  - Union Drilling
  - Baroid Mud Services
  - McJunkin Tubulars
  - Stratagraph NE Mud Logging
- Site Supervision
  - Proactive Health and Safety
  - Laurel Oil and Gas

## Reservoir and Caprock Characterization - Vendor Selection

- Sample and Data Acquisition
  - Dowdco Coring Services
  - Schlumberger Wireline Services
- To Be Determined
  - Bit Supply
  - Cement
  - Core Analysis
  - Brine Analysis

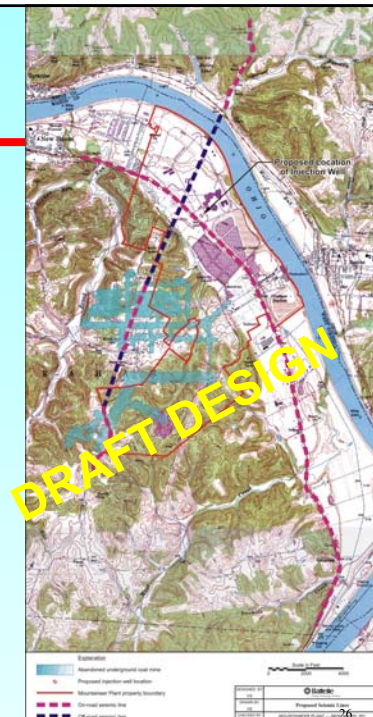
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## Reservoir and Caprock Characterization – Seismic Survey

- Appalachian Geophysical, an Ohio-based company, has been selected for seismic data acquisition
- Schlumberger – WesternGeco will provide design guidance, data processing, advanced analysis, and interpretation
- This arrangement provides local expertise and experience as well as state-of-the-art data analysis
- WVU, Ohio Geological Survey, and others are providing technical input



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## Reservoir and Caprock Characterization – Designing the Deep Test Well

- Iterative process in consultation with WV DEP, Schlumberger, BP, independent petroleum geologists, and others
- Borehole will be advanced with rotary drilling rig using standard oil and gas industry methods
- Multiple casing will be installed to seal off potential drinking water, unstable zones, and  $H_2S$ .
- Final (production) casing will not be installed yet
  - Leave borehole open around potential injection zones for additional monitoring or testing in future
- Casing, cement, and wellhead materials used will need to be compatible with expected use
  - The project has generated research and testing opportunities for development and testing of new materials.

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## Reservoir and Caprock Characterization – Proposed Well Location



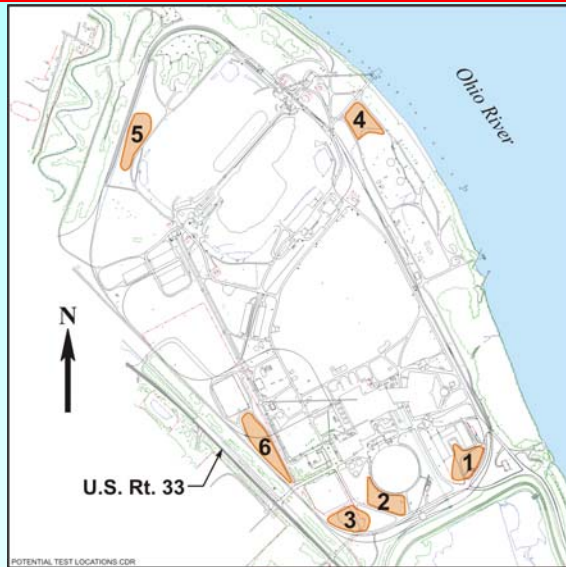
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## Reservoir and Caprock Characterization – Deep Well Candidate Locations

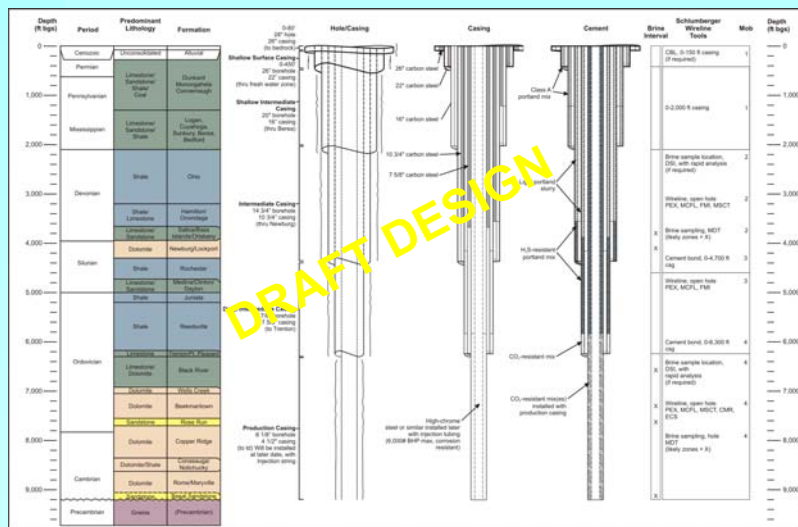
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## Reservoir and Caprock Characterization – Design for the Deep Test Well



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## Reservoir and Caprock Characterization – Drilling the Deep Test Well



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Example of Drill Rig

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## Reservoir and Caprock Characterization – Laboratory Analysis

- Physical, chemical, and mineralogical testing of cores
  - Porosity, permeability, relative permeability, mechanical properties etc.
  - Petrographic and Mineralogical tests including SEM and XRD
- Brine analysis
  - TDS, conductivity, pH, specific gravity, TPH
  - Major elements (ICP), isotopes for brine history interpretation
- Visual interpretation of core slabs

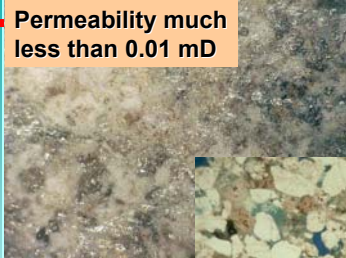
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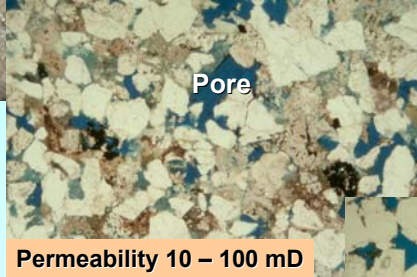
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## Reservoir and Caprock Characterization – Microscopic View of Sedimentary Rocks

Permeability much  
less than 0.01 mD



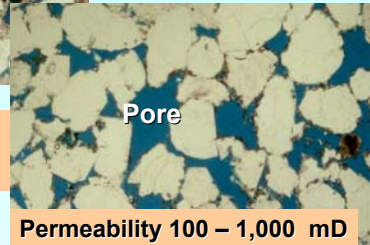
Shale with Extremely Low Permeability  
Forms Good Caprock



Sandstone with  
Medium Permeability  
Forms Good Host  
Reservoir

Permeability 10 – 100 mD

Sandstone with High Permeability  
Forms Excellent Host Reservoir



Permeability 100 – 1,000 mD

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## Reservoir and Caprock Characterization – Data Collection and Use

- Data collected in this task will be used for:
  - Conceptual Geologic Model
  - Risk Assessment and Risk Model
  - Injection and Monitoring System Design and Permitting
  - Scientific Research
  - Stakeholder Communication

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## Framework for Potential Future Phases – Advanced Reservoir Simulations

- The hydrogeologic data from field effort will be used to simulate for CO<sub>2</sub> injection at the site and reactions between CO<sub>2</sub>, brine, and rocks
- STOMP-CO<sub>2</sub> code will be used for most reservoir simulations. Code is being used for the project under Battelle/PNNL Carbon Management Initiative funding.
- Additional codes may be used to address specific questions – e.g., CBM injection

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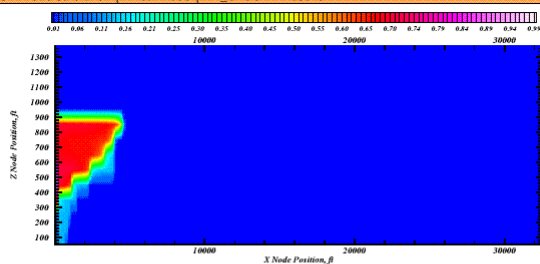
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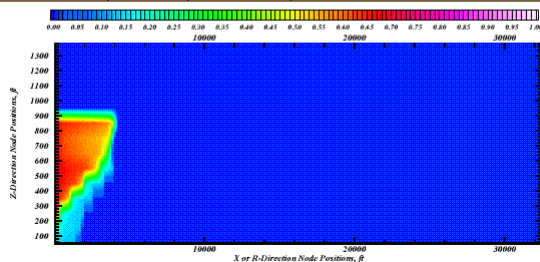
## Framework for Potential Future Phases – Advanced Reservoir Simulations

- STOMP-UTCOMP comparison for Mt. Simon Sandstone field-scale example

UTCOMP/Gas Saturation | 24 Jan 2003 | BP UTCOMP Results



STOMP/Gas Saturation | 24 Jan 2003 | STOMP w/ Salinity w/ Constant Diffusion Coeff.



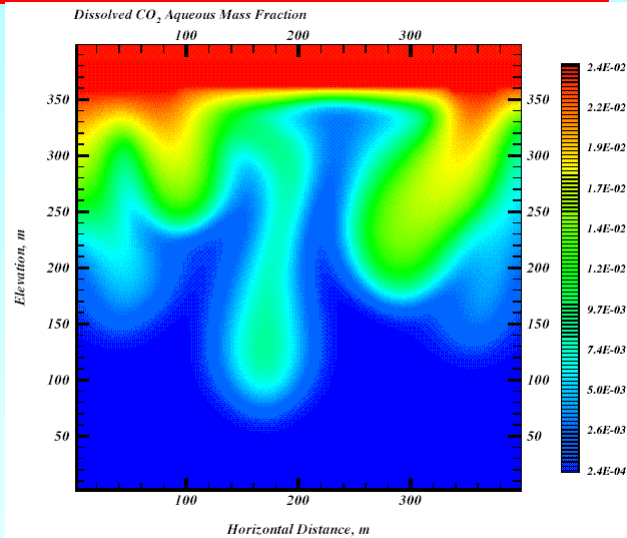
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## Framework for Potential Future Phases – Advanced Reservoir Simulations

- Example:  
Dissolution of  
 $\text{CO}_2$  and  
Rayleigh  
convection cells  
at field-scale



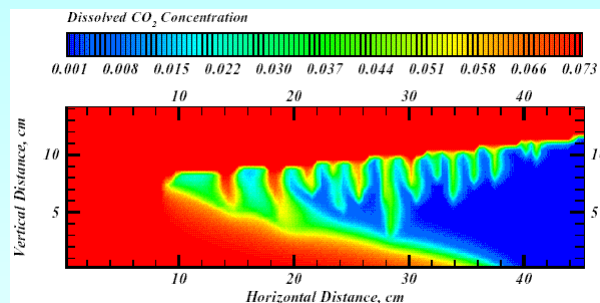
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## Framework for Potential Future Phases – Advanced Reservoir Simulations

- Example: STOMP Simulation at laboratory-scale experiments



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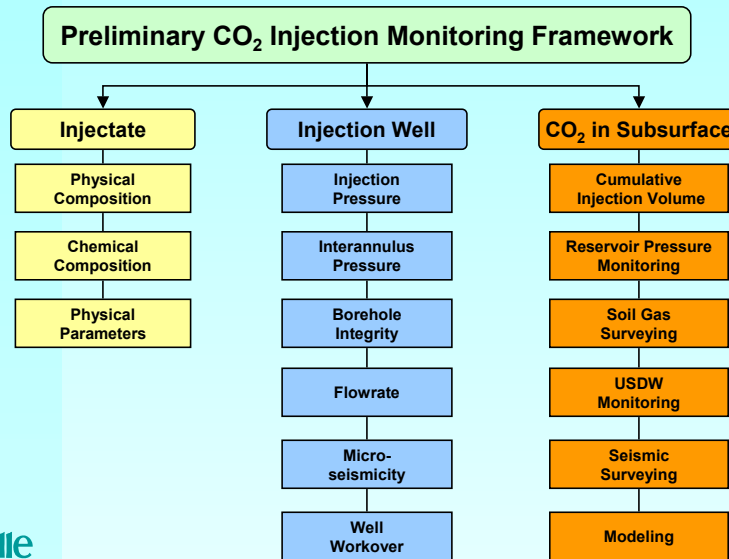
## Framework for Potential Future Phases – Injection Facility Design

- The injection system will be designed based on the findings of field characterization and simulations
- Multiple injection reservoirs – Deep Saline Formations, Coal seams, black shales may be tested
- Multiple injection wells or multilateral wells may be considered
- NEPA EA and UIC permits will be prepared based on the proposed design

## Framework for Potential Future Phases – Monitoring Plan

- A detailed monitoring plan will be prepared to determine the fate of injected CO<sub>2</sub> and provide a protocol for future demonstrations
- The monitoring plan will take into account the:
  - Monitoring required under UIC permits – Regulatory Monitoring
  - Monitoring needed to address scientific and carbon management aspects of CO<sub>2</sub> sequestration – Performance Assessment Monitoring
- Both surface monitoring and in-situ monitoring in deep wells will be considered
- The experimental monitoring technologies may be tested

## Framework for Potential Future Phases – A Systematic Monitoring Framework



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## Framework for Potential Future Phases – Risk Assessment

- Potential risk to human health and the environment associated with the capture of CO<sub>2</sub> and its geologic disposal might result from:
  - Capture, cleaning, and effluent handling system
  - CO<sub>2</sub> leakage from the geologic structure
- Current project is focused on the scientific exploration of the acceptability of the geologic structure for CO<sub>2</sub> disposal, therefore, the risk assessment will focus on potential risks associated with CO<sub>2</sub> leakage
- Human health will be primary focus (ecological receptors secondary importance in this phase)

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## Risk Assessment – Proposed Approach

- Follow EPA/NAS 4-Part Risk Assessment Paradigm
- PNNLCARB model to evaluate hazards associated with leaking CO<sub>2</sub> concentrations and fluxes (combines probability data and consequence data)
  - Risk =  $P_H C_H$
  - $P_H$  is the probability (frequency) of occurrence  $C_H$  is the consequence score assigned to the predicted hazard (i.e., emission flux or concentration in an environmental medium)
- STOMP model will be used to assess potential leakage fluxes for those pathways addressed by the STOMP model
- Stand-alone atmospheric model may be used if more in-depth atmospheric dispersion analysis is required

### HAZARD ASSESSMENT

Identify/document (from scientific literature) potential health hazards associated with exposure to CO<sub>2</sub> and chemical co-constituents

### DOSE RESPONSE ASSESSMENT

Identify/document (from scientific literature) health-based benchmarks (NIOSH/OSHA/ACGIH Exposure Limits in Air, Reference Doses, Cancer Slope Factors) that describe the relationship between exposure and health effect for CO<sub>2</sub> and chemical co-constituents

### EXPOSURE ASSESSMENT

Use models to **predict** possible concentrations and extent of (CO<sub>2</sub> and co-chemicals) in the environment (air, water, soil) resulting from CO<sub>2</sub> leakage

### RISK CHARACTERIZATION

Develop quantitative estimates of the magnitude and probability of adverse health effects resulting from leakage by comparing predicted concentrations or doses to health-based benchmarks

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## Conclusions

- During the last few months we have made substantial progress on all early milestones for this project
- A strong foundation has been laid on framing the project team, geologic framework determination, and execution of stakeholder and public perception issues
- We are well positioned to move into the field work phase of the project
- Overall the program is on track to meet all the objectives in a timely manner

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## Anticipated Accomplishments

- By the end of this project in late 2003, we hope to have laid the foundation for a CO<sub>2</sub> injection and monitoring facility including:
  - Determination of key geologic features near the Mountaineer Plant
  - Quantification of CO<sub>2</sub> disposal potential
  - Characterization and construction of a deep well for potential use in CO<sub>2</sub> disposal
  - Application of simulations to predict CO<sub>2</sub> and movement
  - Design and monitoring plans for a long-term CO<sub>2</sub> Injection facility at Mountaineer
  - A comprehensive risk assessment for CO<sub>2</sub> Injection at this site
  - Preparation of regulatory permits for CO<sub>2</sub> Injection
  - Development of a stakeholder dialogue process

